Husbandry and Care of Carnivores (Chapter 28, ZOOKEEPING)

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Introduction and Natural History

The mammals classed in the order Carnivora are extremely diverse. There is a total of 274 species in this order comprising mammals of diverse sizes, structures, and behaviors. Additionally, animals in the Carnivora group reside in a wide variety of ecosystems and occur naturally on every continent except Antarctica and Australia (Carnivora species have been introduced to Australia by humans over approximately the last 5,000 years). Members of the order live in a variety of ecosystems, from tropical rain forests (e.g., jaguars [*Panthera onca*]), to arid savannah (e.g., cheetahs and wild dogs), to mountains (e.g., snow leopards) and the polar tundra (e.g., polar bears). The pinnipedia are aquatic members of this order (living primarily or solely in water), but they will be discussed in chapter 31. Although the name of the order Carnivora literally means "eaters of flesh," this group includes a wide variety of foraging and digestive strategies, well beyond carnivory. The term "carnivore" will be used throughout this chapter, but in this usage the term does not refer to specific taxonomy or diet, but will be used as a general grouping of animals based on husbandry and care needs (and thus will not include the pinnipeds; see table 28.1).

This taxon maintains a variety of social structures. Some carnivore species (e.g., tigers, leopards, polar bears, pandas, ferrets) live singly in the wild with the exception of females with their young. In these species, the males and females are together only during mating. After the young are born, the female raises them with no assistance from the male. Other carnivores live in groups such as packs (wild dogs), clans (hyenas), mate pairs (maned wolves), or prides (lions). In these species, the males and females remain together after the young are born, and both (or, in some species, all animals in the pack) contribute to rearing the offspring.

All members of this order are well equipped for hunting and eating other animals, and have teeth, claws, and binocular vision adapted for the task (this does not necessarily dictate their foraging strategy, however). Carnivores have comparatively large brains, and the structure of the skull and dentition (teeth) make this taxon different from others (Christiansen and Adolfssen 2005). The type of uterus and placentation and the position of the nipples also assist in classifying species into this taxon. Interestingly, successful "taming" or behavioral modification of an individual (Driscoll, Macdonald, and O'Brien 2009) is possible for certain carnivore species, including but not limited to (hand-raised) cheetahs, raccoons, and some foxes. In comparison, other species such as spotted hyenas, large bears (polar and grizzly) and the great cats (e.g., lions) are not regarded as being easily tamed by humans (Driscoll, Macdonald, and O'Brien 2009).

Carnivores "mark" or demarcate their ranges by urinating and defecating in specific areas. Demarcation also is used by many species during mating, as the sense of smell is heightened in most carnivores and chemical cues in urine and feces are a critical mode of communication.

Carnivores are primarily either nocturnal (active mostly at night) or crepuscular (active during the dawn and dusk hours), although a few species are considered diurnal (active during daylight). Carnivores in general hunt a variety of prey including small mammals, birds, antelope, and deer. However, members of this order can be omnivorous (canids, ursids, viverrids) or even primarily herbivorous (giant and lesser [red] pandas). In general, a primary role of the carnivorous members of the order Carnivora within their ecosystems is to hunt prey species, thereby managing the numbers of these populations. Although most carnivores are opportunistic and will eat whatever they can hunt, they often target sick, weak, or elderly prey animals, thereby maintaining the overall health of these populations. Interestingly, members of the Hyenidae and Procyonidae families can act as scavengers within their ecosystems, a unique role not shared by species from many other orders. There are also members of this taxon, such as maned wolves (*Chrysocyon brachyurus*) and some Viverridae species, that supplement their diet with fruits and other plant matter, often with seasonal regularity. Many species within the carnivores have specific and even limited dietary preferences or requirements. For example, the giant panda consumes primarily bamboo, although it will also eat insects, birds, and small mammals. The black-footed ferret dines almost exclusively on prairie dogs (*Cynomys ludovicianus*) while the fishing cat

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TABLE 28.1. Eight families in the order Carnivora are the focus of this chapter.

• Canidae (e.g., dogs, foxes, coyotes) • Ursidae (e.g., bears) • Mustelidae (e.g., otters, mink, ferrets) • Procyonidae (e.g., raccoons) • Felidae (e.g., cats) • Viverridae (e.g., genets, civets, linsangs) • Herpestidae (e.g., mongooses, fossas) • Hyenidae (e.g., hyenas, aardwolves) Unique members of this order for which taxonomic orientation has recently been under contention include the well-known giant panda (*Ailuropoda melanoleuca*) and the lesser panda (*Ailurus fulgens*, also known as the red panda). These two panda species have been classed in both the "bear" (ursidae) and "raccoon" (procyonid) families. Currently, most experts have them classified in the ursidae group (Olaf and Bininda-Emonds 2004).

(*Prionailurus viverrinus*) has unique behavioral and skull modifications for hunting fish, shellfish, and other aquatic animals (Macdonald, Loveridge, and Nowell 2010, 54-55).

This chapter will describe basic principles for working successfully with a variety of carnivore species in a zoo environment. After reviewing this chapter, the reader will understand

• the basic anatomy of carnivore species
• guidelines for housing and caring for carnivores in zoos
• effects of species biology on enrichment and training programs
• specific reproductive and veterinary issues for mammals of this order
• key conservation initiatives for carnivore species.

Basic External Anatomy

The external anatomy of each family of carnivore is unique. Most carnivores are sexually dimorphic, meaning that the male is larger than the female. Felidae are native to every continent except Antarctica and Australia, requiring a variety of adaptations for each species to thrive in its individual ecosystem. Virtually every species of the felid family has distinct markings, such as spots or rosettes that provide camouflage, except for the puma (*Puma concolor*), jaguarundi (*Herpailurus yaguarondi*), and lion (*Panthera leo*), which are uniform in color (Werdelin *et al.* 2010, 78-80). The 37 total species of felids are divided generally into large (e.g., lion, jaguar, leopard, tiger) and small species (e.g., ocelot, black-footed cat, fishing cat). The claws of each felid species except the cheetah, are completely retractable. In contrast, the claws of canidae are not retractable. Canids are known for long legs, pointed ears, and a long muzzle, which improves their sense of smell. Species in this family live and hunt in packs and occupy almost every major type of ecosystem worldwide. Ursidae are short-tailed, large bodied carnivores with shaggy coats and nonretractable claws. Most bear species are omnivores and have an excellent sense of smell.

The hyenidae family contains only four species, but they likely have the most unique anatomical and social structures of all carnivores. In a clan (group living together) of hyenas, the females are dominant over the males (Holekamp 2006). Hyenidae are found in Africa and Asia and are primarily scavengers, although they are also very skilled hunters (Holekamp 2006). They are known for extremely strong jaws and heavy musculature of the skull, which enables them to crush and consume the entire carcass, including bones and hooves, of their prey (Tanner *et al.* 2010). The bones and other calcified parts of the prey are digested in the hyena's large (capacity of up to 14.5 kg) stomach.

While most Mustelids are strictly carnivorous, the range of items they consume is quite broad, and it occasionally includes plant material. Mustelids as well as herpestids have scent glands and completely nonretractable claws. Herpestids, being more arboreal than other members of the order, are regarded for their ability to attack and kill poisonous snakes, but more often consume other small mammals, birds, eggs, and occasionally fruit. The claws of the procyonid species are short, curved, and either nonretractile or semiretractile. These animals usually have a single coat color with facial and/or tail markings. Some procyonids have prehensile tails, such as the kinkajou (*Potos flavus*), or semiprehensile tails, as in the coatis (genera *Nasua* and *Nasuella*), which help with balance and climbing. Viverrids are likely the least understood of the carnivores; species of this family live in small areas, usually in heavy forest and dense vegetation. Some viverrids that are found in zoos include binturongs (also known as "bear cats") and the fossa (*Cryptoprocta ferox*). The secretions from the musk glands of the civet species (members of the viverridae family) are used in the perfume industry, making these carnivores economically important in some regions.

The Zoo Environment

Because this taxon contains mammals of diverse size and behavior, it is logical that there is great diversity of adequate enclosure size and structure. When considering the ideal temperature, lighting, substrate, and fencing for any carnivore, the natural biology as well as the ecosystem where the species lives in the wild should be taken into careful account. For example, the clouded leopard (*Neofelis nebulosa*) lives secluded, primarily in treetops of evergreen tropical rainforests of Southeast Asia (Macdonald, Loveridge, and Nowell 2010, 16-17). In contrast, the polar bear (*Ursus maritimus*) resides strictly in the arctic where it hunts in the sea ice and survives primarily on seals (Wiig, Aars, and Born 2008).

In the way that each species maintains unique structure and behavior, the ideal substrate and enclosure type also varies. Some examples of substrates that may be used alone or in combination include concrete, gravel, grass, dirt, mulch, and

sand. Safety of animal care staff is of utmost importance when considering housing large carnivores in zoos. The larger species of this order can be housed successfully in a combination of indoor and outdoor enclosures. The strength of the fencing, doors, buildings, and dens must be adequate for each individual species. Also, the size of the holes in the fencing (if mesh is used) must be carefully considered, so as to prevent limbs or heads (especially of offspring) from becoming tangled or stuck in the mesh. Some species are prone to chewing, and breakage of teeth on metal fencing can occur. A covered shelter should be provided at all times for all species. Indoor holdings with adequate heating sources are necessary for any warm climate animals living in cold environments. In general, every carnivore should have access to an "off-exhibit" or secondary holding area in which it can be secured by the keeper. This allows the keeper to enter and clean the primary holding area safely. Also, use of a secondary holding area allows the keeper to feed carnivore species safely (discussed below) and can provide a safe, secure, and secluded area for the animals away from the public.

For certain species, such as lions or large bears, the ability to bring individuals off of an exhibit and into a secure structure each night is a requirement for safety, especially for zoos in urban areas. Many felids (e.g., jaguars, leopards) climb extremely well, and for them completely covered enclosures are imperative. Other large carnivores (e.g., cheetahs, wild dogs) are contained adequately with fencing systems that have overhang of fencing angled back 45 degrees inward over the enclosure (Ziegler-Meeks 2009,15). Electric or barbed wire is not indicated for primary containment, but is used simply to keep animals away from specific parts of the enclosures (Tilson 1995, 25). Buried fencing that extends one meter (three feet) vertically parallel to the bottom of the fence (also known as a dig-out barrier) is essential in exhibits for species prone to digging. More modern-appearing zoo exhibits have creatively and safely used thick glass, moat systems, or other similar setups. Staff should carefully consider the most current recommendations, while always taking into account species biology, for facility design and animal containment for each individual carnivore species (e.g., depth and width of moats for large felids and certain bears) (Tilson 1995, 25; Polar Bear Care Manual 2009,15).

A system of doors and chutes is extremely helpful in moving large carnivores safely from one enclosure to another (often referred to as "shifting"). Small animal entry systems either between enclosures or between interconnecting buildings with outdoor enclosures are beneficial. Secondary containment (e.g., two fences around an enclosure) is recommended for any large felid, due to risk of injury to humans if direct contact occurs. Specific species are primarily terrestrial (e.g., canids and hyenids), while others are primarily arboreal (e.g., clouded leopards, jaguars, some viverridae and procyonidae),

Good Practice Tip: For safety, keepers should wear steel-toed boots and always carry a communications radio when working with carnivores. Keepers should not wear dangling jewelry, loose clothing, long unsecured hair, or any equipment, such as name badges or sunglasses hanging on strings or chains, that could get caught in fencing or doors or grabbed by an animal.

and enclosures should be constructed to reflect the natural tendencies of each species. This can also help with reducing stress or boredom.

Live plants are recommended for the enclosures of most carnivores. Even though most members of the order Carnivora are considered carnivores, they will consume some plant material. For this reason, all plant material included in exhibits should be evaluated for toxic properties associated with ingestion. Shade in the form of trees, bushes, and live plants (such as pampas grass) are recommended for all species housed outdoors or with outdoor access. Individuals benefit from natural materials such as logs for sharpening claws, mounds or elevated spots for surveying territory, climbing trees for enrichment and privacy, and tall grasses and bushes for concealment. A combination of substrates is recommended for carnivores, but more than 50% natural substrate is ideal. A floor made of hard substrate (e.g., concrete) is useful for helping to wear down nails, and can also be well disinfected. But limiting carnivores to only a concrete (or similar manmade substrate) floor can cause damage to foot pads, especially in species prone to pacing. All substrate used in facilities housing carnivores should provide adequate drainage so as to prevent any standing water. All natural substrates should be checked regularly for signs of digging near fence lines. For some species, especially bears and some canids, digging allows for denning and other natural behaviors.

Smaller species of felidae are frequently housed in indoor enclosures very successfully. Habitats where each species naturally occurs in the wild should be considered in the care of any zoo animals, and staff should be aware of the most current housing and facility recommendations for each species or taxon. For example, the sand cat (*Felis margarita*) is native to extremely dry and hot areas of Africa (the Sahara) and Central Asia (the Arabian Desert). These environments have a wide range of temperatures, as the daytime temperatures can easily reach 45°C (113°F) in summer while the nighttime temperatures can plunge to 0°C (32°F). An enclosure for this species would need to be carefully maintained for low humidity, natural substrates (sand), and higher temperatures than for most other species of this order.

Other small carnivore species are also housed completely indoors with great success. In general, the indoor enclosure temperature should be

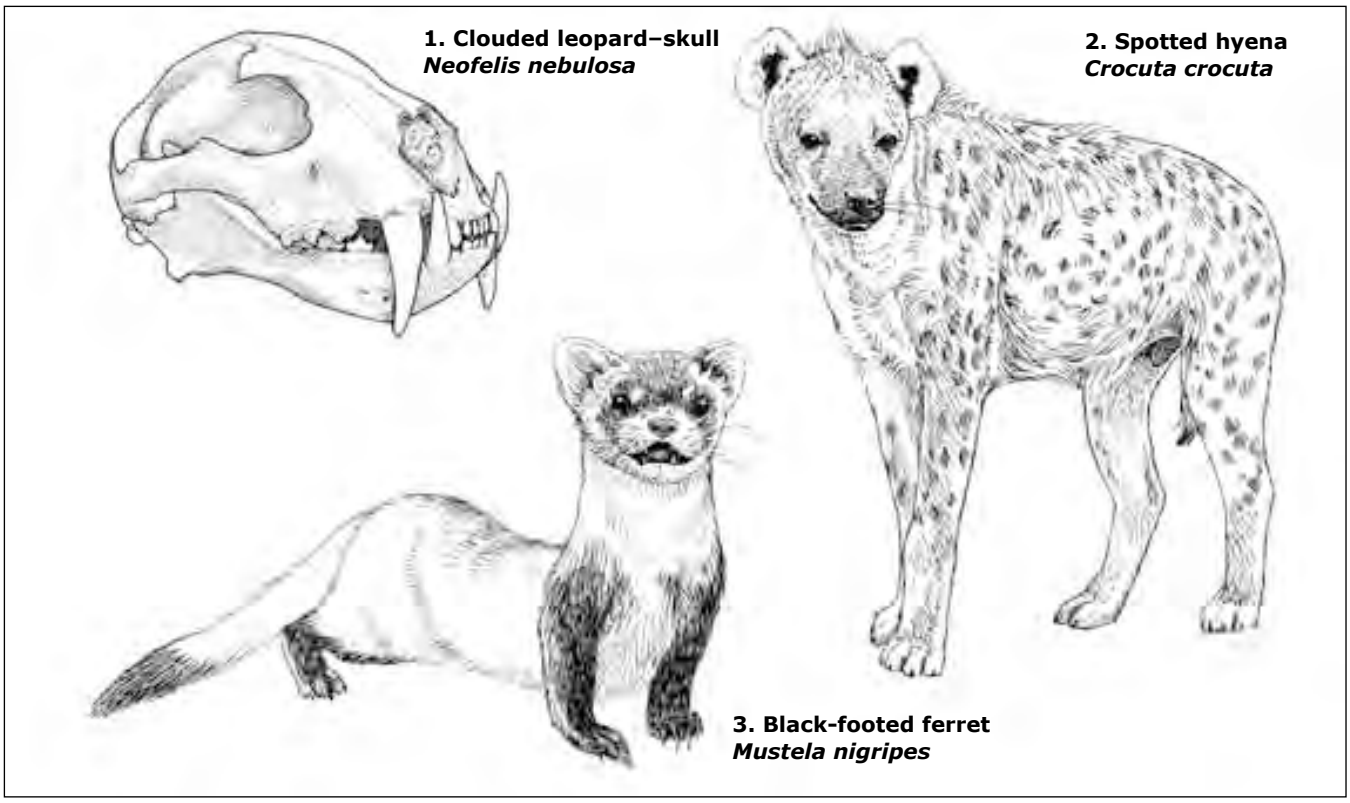

Figure 28.1. Examples of the diverse morphology of species within the order Carnivora: (1) the skull of the clouded leopard (*Neofelis nebulosa*) depicts that this species has the largest canines of any living Felid, relative to body size; (2) it is very difficult to differentiate a male from a female spotted hyena (*Crocuta crocuta*), due to the masculinization of the female genitalia; (3) the black-footed ferret (*Mustela nigripes*) of the North American plains dines almost exclusively on prairie dogs (*Cynomys ludovicianus*) and this species was once reduced to only 18 total individuals due to indiscriminate removal of their preferred prey. Illustrations by Kate Woodle, www.katewoodleillustration.com.

maintained at 13 to 18 °C (55 to 65 °F) in winter and 18 to 21 °C (65 to 70 °F) in summer. However, the specific temperature requirements may vary with specific species' needs on the basis of the environment they occur in naturally. Tropical and subtropical forms should be housed indoors if the temperature is expected to fall below 60 °F. A general recommendation is for relative humidity to be between 30 and 70% indoors for mustelid, viverrid, and procyonid species. The higher end of this range (55-70%) is needed for the tropical forest species and the lower end (approximately 30%) is required for the desert species (Procyonid Care Manual 2010; Viverrid Care Manual 2010). The families herpestidae and mustelids are comprised of animals that primarily reside in burrows (Mustelid Care Manual 2010). Species of these families depend on intricate burrow systems for shelter, food, and protection from larger carnivores. Some species thrive on manmade burrow systems; however, other species seem to need to dig and produce their own burrows (John Stoner, pers. comm.). All indoor facilities for any carnivore should be well ventilated.

Nest boxes are widely used for many smaller carnivores. These are typically wooden or plastic structures that provide safe places for animals to hide and are ideal for the birth of young. For smaller species, these boxes should be elevated above the ground to help keep out pests and provide additional security. Many zoos will place a variety of structures, called furniture, in an enclosure. For carnivores these structures include logs, tree limbs, pools, rocks, walking and climbing ropes, and platforms, among other items. This furniture should be cleaned and rearranged regularly, and use of specific items is dependent on the species. For example, introduction of a climbing rope would not be beneficial for a lion and could even be potentially dangerous, whereas a red panda would benefit greatly from the exercise and enrichment a rope offers.

Basic Husbandry

Special precautions inherent in caring for carnivore species are associated with the safety of the keeper staff and the individual animals. The integrity and security of each enclosure should be examined very carefully each day. Each individual animal should be located and accounted for, and each enclosure should be visually examined carefully by the keeper first thing each morning. This is especially important before a keeper enters any area that could contain a large carnivore species, to ensure that there has been no breach in security. The keeper should look for foreign or sharp objects that could cause injury, as well as any potential breaches to fencing. All doors and shifts within the enclosure of any large carnivore must be lockable. The enclosure should be

carefully checked for any signs of vomiting or diarrhea, which indicate possible illness. Healthy animals will be alert and responsive to noise and visual stimuli. Disinterest in food, lethargy, poor skin or hair coat, and a depressed attitude are all signs of possible illness. All animals should be checked carefully by the keeper at the end of each day. All gates and doors should be checked to ensure that they are closed and locked. All the animals should have adequate access to shelter, food, and water, and each individual should be comfortable and secure.

Both metal and rubber food and water bowls can pose risks to carnivores. For certain species, especially those prone to chewing, metal poses a risk of breaking or damaging teeth. Rubber receptacles are very enticing for animals to chew on, and the risk of ingestion of rubber pieces is high. Hard plastic bowls are easy to clean and disinfect, and they are too sturdy for most carnivores to break or chew. Many zoos use stainless steel bowls, which are very unlikely to be broken by a large carnivore and can be sterilized easily. For lions or tigers, feeding on bare substrate such as concrete may be appropriate. Bears naturally forage for their food in the wild, and mimicking this in zoos can help reduce boredom and provide enrichment. Food for ursid species is often scattered or hidden throughout an animal's enclosure to stimulate this foraging behavior.

A basic rule for feeding a carnivore is to move it to a holding area where it can be well secured away from the keeper. Food is then placed into the enclosure where the keeper wants the animal to eat, and the individual animal is allowed back into the enclosure after the keeper has safely departed. Some groups of carnivores will need to be separated and fed individually to prevent fighting over food. This feeding strategy also allows the keeper to make sure each animal is consuming its prescribed diet, observe any change in its eating habits (e.g., not finishing the offered diet, eating more slowly than usual, regurgitation), and measure the amount of diet consumed. Other species will eat successfully in groups; the decision whether to feed an animal individually or in a group should be based upon its natural history as well as its individual temperament.

The goal of feeding carnivores in a zoo setting is to offer them a diet that meets their nutrient needs in a palatable and readily digested form. Forms of carnivore diets include commercial raw meat mixes, canned and dry pet foods, and whole prey (carcasses). Many carnivores eat only once every few days in the wild, and gorge themselves on portions of a comparatively large carcass after a hunt. However, in most zoo settings where such large whole carcass feedings are neither practical nor accepted by staff or visitors, each individual may be fed many times per week, if not every single day. Many facilities have adopted "fast days" for carnivores, either to loosely mimic the fact that they do not eat every day in the wild or to encourage them to focus their efforts on bones or similar hard "food" items for their improved dental health. Numerous published guidelines are available through species and taxa specific interest groups (AZA, SSP, and TAG programs) and scientific advisory groups associated with zoo and wildlife nutrition.

Obtaining regular body weights is an objective and extremely useful way to monitor adequate food intake as well as overall health. Smaller carnivore species can often be weighed easily and readily by using a small transport carrier to place the individual on a scale. A free-standing platform scale can be used for some larger species that can be trained to stand on the device for food or a similar reward (discussed below). Other species that are larger or difficult to train may require the use of squeeze or crush cages fitted with scales. In situations when regular measurements of body weight are not readily available, assessing body condition is one way to determine whether each individual is receiving an adequate diet (thus maintaining its appropriate body condition). Body condition scoring is the practice of visually assessing the amount of tissue covering specific bony structures on the body as a measurement of the body's condition. This method does require some degree of training and experience to be done accurately and consistently. Carnivores have simple stomachs designed to process readily digestible food items (meat, fish, whole prey), as compared to the more complex digestive systems of herbivores. Recent work has suggested that some species of felids may actually have the ability to ferment some of the less easily digested components of their diet (hair, cartilage, digestive tract contents) in a fashion similar to that of herbivores. Interesting to note within the carnivores is the giant panda: a simple-stomached carnivore in form and function, but an obligate herbivore (nearly 100% bamboo) in practice.

Carnivores require access to clean, fresh water in clean receptacles. Each species will consume a different amount of water, in accordance with its natural dietary intake and metabolic requirements. Most cat species get the bulk of their moisture from the food they eat. Some carnivores tend to urinate or defecate in standing water, so cleanliness of their water supply must be checked daily. In cold temperatures it is necessary to check that water sources are not frozen. If necessary, heated, plug-in water bowls can be used in animal buildings during periods of cold temperatures for certain species. Care should be taken with species that are prone to chewing, and any electric cables should be protected to prevent damage.

Equipment and Handling

Knowledge of the species, and especially of each individual's behavior and temperament, is critical when discussing the handling of a carnivore. Three types of restraint are generally used for carnivores: physical, chemical, and behavioral. Physical restraint involves using force alone to prohibit an individual's movement (Christman 2010,39). Large carnivore

species are not usually handled directly, except when they are very young and can be controlled safely. For restraint of large carnivores such as bears, the great cats, and hyenas, use of a remote mechanical squeeze cage or chute is recommended. These are usually permanent structures that are integrated into the animal's enclosure. This integration enables its regular use and training by keepers, and enhances each animal's comfort with the restraint device. Certain carnivore species may be tractable enough for keepers to work with directly in the enclosure throughout adulthood (some examples include cheetahs, smaller felids, maned wolves, ferrets). However, some specific individuals of a species may never be considered safe enough for a keeper to have "free contact" (no barrier between keeper and animal) with them, and push boards, proximity sticks, and/or shields may be required for working with them in a free-contact situation. If the offspring of larger felids are to be handled for weighing, vaccines, or other routine exams, thick leather or mesh gloves are required. Nets, nooses, kennels and ropes can be used for physical restraint of small to midsize carnivores (Christman 2010, 43-46). Smaller members of the order Carnivora tend to fight back and become aggressive when being handled or restrained, and there is a high risk of animal care staff being bitten or scratched. Wire cages, thick gloves, and often face shields or visors are recommended for restraint of small carnivores such as mink or ferrets (Christman 2010, 43-45).

Chemical restraint is the use of sedatives or anesthetics by a veterinarian (Christman 2010, 40). These agents should be administered and used only by licensed veterinarians, so they will not be discussed further in this section. Behavioral restraint involves the use of training and/or behavioral modification to enable the keeper to handle, manipulate the activity of e.g., in weighing), or administer medications to an individual animal. Behavioral restraint will be discussed in the following section.

Behavior

Stressors are stimuli an animal experiences that cause a biological response. The first reaction of most animals to a stressor is a state of heightened awareness. If exposure to the stressor (either positive or negative) continues or increases, there is often an associated physiological response of increased glucocorticoid (Cortisol) concentrations. For example, moving to a new enclosure can cause a felid to have a spike in glucocorticoids. This occurs when the new environment is novel and stimulating, not necessarily because it is frightening or intimidating, and it could be considered a positive stressor or stimulus. In contrast, transportation to the veterinary hospital for a routine exam can also cause an increase in glucocorticoids, because the animal is nervous and unsure. This would be considered a negative stressor or stimulus for that individual. All animals react to sudden changes in their environments and are generally categorized into having either a "fight" or a "flight" response. This refers to how animals naturally respond to changes in their environment. Carnivores generally respond by fighting, and rarely fleeing, from danger or novel stimuli.

Some species (small and mid-size felids) display a combination of these behaviors, in that they will initially move away from a perceived threat (flight) but respond with aggression (fight) if cornered. Large felids, canids, bears, and hyenas can be very aggressive and can pose a high risk to keeper safety. These natural behavioral tendencies are important to understand, and such an understanding will improve the keeper's ability to manage and work safely with carnivores.

Training

Traditionally, when managers needed to handle, weigh, vaccinate, or medicate zoo animals, the animals were restrained either physically or chemically. In recent years, however, the zoo community has moved towards behavioral restraint through training programs and behavioral modification. Carnivores, like most mammals, are successfully trained by positive reinforcement. They are naturally motivated by food, so preferred dietary items are often ideal rewards during training exercises. Human safety is a primary concern when training any carnivore, especially when rewarding animals with food. Keepers should always be prepared to quickly end any training session if an emergency arises; a quick release or escape from the area, for both animals and keepers, should always be available if necessary. Animals can become agitated during training sessions, increasing the risk of injury to themselves or keepers. As a general rule, veterinary staff should be notified before training sessions begin.

Enrichment

Enrichment for carnivores is varied depending on species, but is deemed a critical part of managing these animals in captivity. Allowing for physical and psychological stimuli in an otherwise static environment can improve their overall health, well-being, and interactions with both conspecifics and keepers. Knowledge of species biology as well as individual animal temperament should inform enrichment programs. Felids are naturally curious and will usually investigate a new addition to their enclosure. Some species are primarily motivated by action (e.g., cheetahs are stimulated by watching or chasing) while others (e.g., canids) are more enticed by smell. Large "boomer balls," Kong® toys, boxes, bags, specialty food items (only with approval of the institutional nutritionist and/or veterinarian), spices, perfume, feathers, melons, and coconuts are all good sources of enrichment for carnivores. Not all enrichment is appropriate for each species. Individual species biology as well as animal temperament should be carefully considered before any enrichment item is introduced. An item that provides positive enrichment for one bear may be

damaged and then pose a risk to another. When an enrichment item is first introduced to an individual animal, the keeper should monitor it closely to be sure it uses the item as intended and does not consume any parts of it. A plan should also be in place for retrieval of the enrichment item if it becomes absolutely necessary.

For smaller carnivores, large soil-filled enclosures can provide extensive enrichment (e.g., for mustelids and herpestidae). The soil is rearranged daily by the animals, providing enrichment, tunnels, and extensive exercise. Tubes also provide enrichment and a place to hide and feel secure. Additional enrichment items such as golf balls, boomer balls, or boxes can be provided if they can be disinfected. Herpestidae are particularly known for opening hard food items (nuts, eggs, crustaceans) with tools such as rocks, and allowing for this natural feeding behavior can provide them with enrichment.

The diet should always be considered enrichment, in possibly its purest form. Even though a commercial meat mix may not appear as outwardly stimulating as a whole carcass, the diet can still be presented in a way that allows the animal to exhibit natural foraging and search behaviors. Whole carcass feeding, whether small or large) is finding increasing acceptance throughout North America as a means to meet not only the nutritional but also the behavioral needs of carnivores.

Transportation

When necessary, carnivores may need to be moved out of their enclosure, thus requiring a transport vessel in which to move them. Reasons for transport can include transfer to a new enclosure not accessible through a door or chute, a veterinary exam, or even relocation to a new institution. Each individual should be made comfortable with the carrier or crate prior to transport whenever possible. Desensitization to the shipping compartment will reduce the animal's stress and make travel easier for it. Smaller carnivore species (mustelids, herpestidae, and smaller felid and canid species) are often transported in carriers used for domestic cats and dogs (e.g., sky kennels). Large carnivores need special cages, with specific requirements for each species. Slatted flooring (with slats that are spaced adequately to prevent toes from getting caught), mesh for proper ventilation, secure locks, and easy visual access to the animal are all required in shipping containers. For lengthy trips, food, and water receptacles must be present. All possible relevant regulatory agencies (e.g., states, the US Fish and Wildlife Service, and CITES) should always be checked for shipping, health, and permit requirements before transporting animals. For general, taxa-specific comments, see the appropriate AZA care manuals. The International Air Transport Association (IATA) also publishes rules for individual species, including specific guidelines for animal transport containers.

Reproduction

Extensive research has been conducted in the field of carnivore reproductive physiology (see Kleiman *et al.* 2010; Macdonald and Loveridge 2010). In general, a carnivore produces a single litter annually, but some species can produce multiple litters each year. Larger species such as bears and the great cats will have gaps of two to three years between litters, as the females are caring for their young. Many carnivores, such as mustelidae, canidae, and some felidae, are highly seasonal. In species that breed seasonally, the females come into estrus or heat only during a specific time of the year, usually for about four months. Males of these seasonal breeders also produce sperm only when females are receptive to mating. Some felid and mustelid species are induced ovulators, meaning that an oocyte is released from the ovary only after mating. Canidae, mustelidae, ursidae, and procyonidae species have a well developed baculum or penile bone. The baculum, used for and during mating, allows the male to extend the length of the copulatory period. The average gestation or pregnancy period ranges from 50 to 115 days, after which time a female gives birth to 1 to 13 young, depending on the species. Species of the ursidae and mustelidae families have delayed implantation, whereby an egg (oocyte) can become dormant for a period of time after its fertilization. This phenomenon makes accurate determination of gestation length very difficult, as it can extend pregnancy six to nine months beyond the normal period.

Carnivores are born underdeveloped, with eyes and ears closed. Cub mortality of carnivores is deemed the biggest contributing factor to poor sustainability in captive populations. Maternal neglect or aggressive behavior towards the newborn can be observed (Ziegler-Meeks 2009, 47-55). General husbandry guidelines for most carnivores suggest a hands-off approach to the management of parturition and neonate care. Specifically, remote monitoring with cameras or other equipment is ideal. Limited keeper presence and involvement is highly recommended so as to reduce stress of the mother and encourage maternal neonate bonding. Carnivore females nurse their young for several weeks or months and often will care for them for several months (e.g., in mustelids and viverrids) or years (e.g., in large cats and bears).

The hyenidae family has the most unique reproduction and social structure of any carnivore (see Glickman *et al.* 2006; Holekamp 2006). The female spotted hyena (*Crocuta crocuta*) is the only mammal that lacks an external vaginal opening (Glickman *et al.* 2006). The genitalia of the male and female of this species are remarkably similar, making sex determination by simple observation difficult. The female spotted hyena has an enlarged clitoris, also referred to as a pseudopenis, through which she urinates, copulates, and also gives birth (Holekamp 2006). The sexes have a linear dominance hierarchy, the lowest female outranking the highest male. The

dominant male in a clan has access to the most females for breeding. The dominant female monopolizes carcasses, which results in better nutrition for her cubs (Hole kamp 2006). A female cub inherits the dominance status of her mother (Holekamp 2006).

Veterinary Care

In general, carnivores are treated for internal and external parasites and also receive vaccinations on a regular schedule. Zoo carnivores are susceptible to the same external parasites as domestic species (ear mites, fleas, ticks), and treatment is achieved using the same agents as would be used for domestic dogs or cats. Animals should be treated for internal parasites on a monthly or quarterly schedule. Fecal samples should be routinely screened to determine the presence of parasites. Vaccinations routinely given to members of this taxa include but are not limited to rabies, distemper, parvovirus, corona, leptospirosis, and feline panleukopenia. Mustelids have varying species and exposure-dependent sensitivities to feline panleukopenia, canine distemper, rabies, and leptospirosis. Most resources recommend vaccination of mustelids for rabies and canine distemper, as well as for canine hepatitis if prevalent (Mustelid Care Manual 2010, 46). Vaccination administered to any group, species, or individual is the final decision of the veterinarian in charge of that specific collection. Species with outdoor housing or access should routinely be administered heartworm preventative in areas where that parasite is endemic.

Felids are susceptible to many feline viral diseases, such as feline immunodeficiency virus (FIV), feline leukemia virus (FeLV), panleukopenia (parvovirus), feline infectious peritonitis (FIP), feline herpes virus, and parasitic diseases such as toxoplasmosis. Wild felids carry toxoplasmosis (*Toxoplasma gondii*), and although that parasite is often carried harmlessly by most mammals, including people, it can have serious adverse effects on humans with compromised immune systems. Pregnant women are advised to not handle cat feces at all, and they should strive to avoid felid enclosures in general (Rosenthal and Xanten 2010, 77). Cats also suffer from feline respiratory disease, a complex of viral contagions including rhinotracheitis, pneumonitis, and influenza, marked by fever, sneezing, and running eyes and nose. Mortality is low, but recovery from severe cases may be difficult and prolonged, with relapses. Antibiotics are used to prevent secondary bacterial infections.

Cheetahs are highly susceptible to herpes virus (ZieglerMeeks 2009, 51-52). Young cubs normally do not show any symptoms until after they are four days old. Early detection offers the best chance for treatment. Minimal signs of infection may clear up on their own in young cheetah cubs. If the dam is actively shedding the virus, injury to the cubs can become quite severe, including lesions of the eyes, nose, and/or mouth. Most symptoms appear by about one month of age. Severe lesions can lead to permanent scarring, including that of the cornea and prolapsed third eyelid (nictitating membrane).

Cystinuria has been found in a significant number of both free-ranging and captive maned wolves. The disease also occurs in humans and canids, and is transmitted genetically. Cystinuria is characterized by excretion of amino acids, especially cystine, in the urine (Bush and Bovee 1978), and can result in difficulty with urination. If the condition becomes severe enough, the animal may become "blocked" (i.e., the urinary tract clogged with insoluble and impassable solids such as crystals) and lose the ability to urinate completely, which can eventually be fatal. A screening program for early detection is recommended.

Epizootic plague kills both prairie dogs and ferrets, and is a major factor limiting recovery of the highly endangered black-footed ferret (Matchett *et al.* 2010). For captive-reared individuals, this has been combated through a combination of vaccinations and treatment for fleas (Matchett *et al.* 2010).

Conservation Programs

Species of the order Carnivora are normally thought of as highly charismatic and usually are public favorites when housed on exhibit in zoos. Unfortunately, most carnivores are viewed as pests and threats to human safety in their wild habitats, and therefore most species are threatened or vulnerable to extinction. Because of their unique place in their respective ecosystems and their vulnerability to human persecution, there are multiple conservation and research programs for carnivores worldwide. Two specific conservation programs will be discussed in this section as examples of successful initiatives for species of this order. There is a plethora of very active and successful programs for carnivore species around the globe, and we encourage anyone working with such species to investigate these programs.

The Global Tiger Initiative aims to protect wild tigers and their ecosystems. The initiative proposes to accomplish its goals through increased community education, reduction of illegal offtake or poaching, and direct protection of tiger habitat. Much of the this program's success will depend on changing people's attitudes. People living with tigers will hopefully learn to value them and desire to maintain them in their ecosystem. In addition, people must see a financial benefit to themselves and their communities from helping to protect tigers. To be successful, the initiative must increase knowledge and understanding of tigers so that people will fear them less and appreciate them more.

The black-footed ferret is an excellent example of a carnivore species that has recovered in the wild due to intense conservation and research efforts. Once thought extinct in the wild, a small population of this species was found in Wyoming in the 1980s. In

1985, a total of 18 individuals were taken from the wild and into captivity. These few individuals became the foundation for the entire future of the species. After years of research and assisted reproduction programs, the species has been reintroduced into the wild. Additional animals are released every year, bolstering the free-ranging population. The success of the black-footed ferret program is due largely to management in zoos and captive breeding facilities, public education, and intense biological research.

Summary

Species of the order Carnivora have diverse anatomy, physiology, and behavior, presenting unique challenges and considerations for managing these animals in zoos. Keepers should research the natural history of any species under their care. A better understanding of a species' biology will improve its daily care, training, and enrichment through the use of best practice methods. Keepers and others involved with the care and management of these species should also investigate and be familiar with current conservation and research programs. The preservation of endangered species benefits from heightened public awareness and appreciation, and the zoo community plays an important role in bringing it about.

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